REMARKS/ARGUMENTS

Claims 1-6, 12-14, and 18-23 remain in this application. Claims 1, 3, 4, 5, 6, 12, and 18 have been amended. New claims 100-104 have been added. Claims 7-11, 15-17, and 24-99 have previously been withdrawn.

Applicants submit herewith an English language translation of German Patent No. 3,635,819 A1. A copy of the actual German language patent was previously filed with the IDS mailed on May 18, 2004, in response to the Examiner's detailed action (page 2) contained in the non-final Office Action mailed 02/18/2004. The Examiner stated therein that "Although there were English-language documents with numbers that correspond to references AM and AP-there was no copy of the actual patents." Applicants respectfully request that the Examiner consider this additional reference and provide applicants with a copy of the signed and initialed Form PTO-1449 submitted with the applicant's May 18, 2004 Amendment.

Applicants respectfully traverse the rejection of claims 1-6, 8-14, and 18-23 under 35 U.S.C. Section 112, second paragraph. There is inherent antecedent basis for "the center of the hole" as well as "the hole positioned along the centerline" and "the centerline". In particular, every hole has a center and the glass object will have a centerline.

Applicants respectfully traverse the rejection of claims 1-6, 12-14, and 18-23 under Section 35 U.S.C. 112, first paragraph. According to the Patent Office, "there is no support for the glass object having an internal wall. The only mention of a wall is the wall (81) of the furnace." Applicants respectfully disagree. Centerline holes can be seen, for example, in Figs. 5 and 5A, as well as the wall that forms the centerline hole 60.

Applicants respectfully traverse the rejection of claims 1-5 under 35 U.S.C. § 103(a) as being unpatentable over Onishi (6,076,376) alone or in view of Glodis (6,105,396). According to the Patent Office, "It would have been obvious to use a pressure at least equal to atmospheric pressure (in the Onishi MCVD process), to prevent atmospheric pressure from collapsing the tube. One of ordinary skill understands that there has to be a balance of pressures to prevent the tube from shrinking." Applicants

respectfully disagree. In fact, prior art hole closure processes that applicants are familiar with involve using considerable vacuum to pull the centerline hole of the optical fiber preform closed. Such vacuums are employed for example, in MCVD processes.

There is no teaching in Onishi of using any type of hole closure technique at all prior to drawing the fiber illustrated in Fig. 12, yet alone a hole closure technique that will result in symmetric hole closure. Instead, Onishi is clearly directed to spinning the fiber to reduce the PMD in the optical fiber, whereas applicants' invention is a method which reduces the PMD in a fiber without having to spin the fiber. While applicants' invention can be used in conjunction with spinning techniques to reduce the PMD even further, the fact that applicant is able to achieve such low PMD without having to spin the fiber, as was necessary in Onishi, evidences the surprising improvement that applicant's invention enables.

The Patent Office indicates that it would have been obvious in view of Glodis to use a pressure at least equal to atmospheric to prevent atmospheric pressure from collapsing the tube in the Onishi MCVD process. As explained above, there is no clear teaching, or even a suggestion, in Onishi that a hole closure process was utilized to manufacture the fibers referred to by the Examiner (Figure 12). Consequently, the combination of Glodis with Onishi would not result in applicant's claimed invention as defined by newly amended claim 1.

Applicants respectfully traverse the rejection of claims 1,2, and 6, 18, 22, and 23 under 35 U.S.C. §103 as being unpatentable over Maurer (RE 28,028). According to the Patent Office, it would have been obvious to perform the process at a pressure of at least atmosphere, so that one does not have to bother with a vacuum system. Applicants respectfully disagree, there is no mention or suggestion in Maurer of using atmospheric pressure, nor is there any suggestion that doing so would result in a process which results in closure of the hole which is present in the Maurer preform.

With respect to claim 6, the Patent Office indicates that it would have been obvious to plug or cap the tube so as to prevent any material from getting into the tube. Applicants respectfully disagree. There is no mention or suggestion in Maurer that would lead one to plug the tube. The Patent Office indicates that column 4, lines 71-72, and

column 7, lines 34-37, provide impetus to modify the teachings of Maurer accordingly. Applicants respectfully disagree. The portion at column 4 indicates that hydrochloric acid washing is desirable, and the portion at column 7 indicates that core and cladding materials need to be of very pure material. However, there is no mention or suggestion that the hole in the Maurer preform should be plugged or closed.

With respect to claims 22 and 23, the Patent Office indicates that "it would have been obvious to maintain the circular symmetry shown in Fig. 3, because there is no reason to change it, and because Maurer teaches variations are undesirable." Applicants respectfully disagree. The portion of Maurer at column 3, lines 30-32 indicate that "variations in core diameter or in either index of refraction may significantly effect the transmission characteristics of a waveguide." This passage is addressed to core diameter, nor core symmetry. This does not suggest to one of skill in the art that the hole of the preform should be closed as symmetrically as possible. In other words, if one takes the same optical fiber and draws it so that the core has a different diameter than a previously drawn fiber from the exact same optical fiber preform, the transmission characteristics of the waveguide will change considerably. This is not the same as maintaining the circular symmetry of the core.

Applicants respectfully traverse the rejection of claims 1-2 and 6 under 35 U.S.C. Section 103 as being unpatentable over Berkey (US 5,152,818).

Berkey does not mention or suggest using an intermediate glass object which has a hole wherein, the center of the hole positioned along the centerline of the glass object. Instead, feature 80 which is referred to by the Examiner in Figures 9-10 and 14 of Berkey, shows a hole which is located off of the centerline of the glass object. According to the Patent Office, it would have been obvious to have the hole close uniformly and symmetrically along the centerline access, so that the fiber will have the same cross-section at every location along its length. Applicants disagree with this statement, as applicants have discovered that the holes can close extremely non-uniformly and non-symmetrically along the centerline axis and the fiber will still achieve the same cross-sectional dimension at every location along its length. This is further evidence of the

surprising results of applicant's invention, which was not mentioned or suggested in any of the references cited by the Examiner.

Applicants respectfully traverse the rejection of claims 1-2, 12-14, and 18-23 under 35 U.S.C. Section 103 as being unpatentable over Berkey (US 5,917,109).

Berkey does not disclose reducing the outside diameter of the glass object under conditions sufficient to cause the hole to close uniformly and symmetrically. With respect to claim 23, there is no mention or suggestion of closing the hole such that the fiber exhibits a radial symmetry of less than .025 μm. According to the Examiner, it would have been obvious to have the fibers as close to symmetrical as possible so that the fibers possess the desired profile of Figure 7 or 8 at every position. Applicants disagree with this statement, as it is very common for optical fibers to be made such that they are not as symmetric as possible, because the degree of non-symmetry does not substantially affect the properties of the optical fiber. For example, the likely cause of the high amount of PMD in the Onishi fiber prior to spinning is due to asymmetry in the fiber. One common way to mitigate the non-symmetry is to spin the fiber, as Onishi suggests, to lower the PMD of the fiber. Applicants invention is directed to a new technique for lowering the PMD resulting in the fiber from non-symmetric hole closure, i.e., closing the hole uniformly and symmetrically so that a low level of PMD can be achieved.

New claims 100-104 are also submitted herewith and consideration is respectfully requested for each of these claims. Applicant submits that each of these claims are directed to the elected invention.

Based upon the above amendments, remarks, and papers of records, applicant believes the pending claims of the above-captioned application are in allowable form and patentable over the prior art of record. Applicant respectfully requests that a timely Notice of Allowance be issued in this case.

Applicant believes that no extension of time is necessary to make this Reply timely. Should applicant be in error, applicant respectfully requests that the Office grant such time extension pursuant to 37 C.F.R. § 1.136(a) as necessary to make this Reply timely, and hereby authorizes the Office to charge any necessary fee or surcharge with

respect to said time extension to the deposit account of the undersigned firm of attorneys, Deposit Account 03-3325.

Please direct any questions or comments to Robert L. Carlson at 607-974-3502.

Respectfully submitted,

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Robert L. Carlson
Attorney for Assignee
Reg. No. 35,473
Corning Incorporated
SP-TI-03-1
Corning, NY 14831
607-974-3502

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(54) METHOD FOR THE PRODUCTION OF A LOW-LOSS OPTICAL WAVEGUIDE

(71) Applicant: Schott Glaswerke, 6500 Mainz (West Germany)
(72) Inventors: Wolfgang Siefert, Volker Paquet
Dieter Krause
6500 Mainz, Hartmut Bauch
6237 Liederbach, Germany
(74) Agent: W. Schmitz, patent attorney, 6200 Wiesbaden

Examination request has been made in accordance with Section 44, Patent Law.

Abstract

Optical waveguides are produced by collapsing inside-coated glass tubes to form a massive blank, then drawing out. Either a doping substance, particularly germanium oxide, can be added to the core so as to increase the refractive index, or the core can be made of pure SiO_2, wherein the areas farther from the core can contain, for example, fluorine, for the lowering of the refractive index. By evaporating germanium dioxide during the collapsing, however, the transmission characteristics of the finished optical waveguide are impaired; optical waveguides produced up to now, with a core of pure SiO_2, exhibit higher losses than theoretically expected. The new method will produce optical waveguides of better quality, with a pure SiO_2 core.

A low-loss optical waveguide with an increased transmission bandwidth and low bending losses, with a pure SiO_2 core, can be simply produced by establishing an oxygen pressure of $p < 10$ mbar in the inner space of the glass tube during the collapsing or during the glass tube drawing-out process.

Production of an optical waveguide.

Claims

1. Method for the production of an optical waveguide--which is made of pure SiO_2, at least in its inner core area--from a glass tube with a suitable refractive index distribution over the wall thickness, by collapsing this glass tube to form a massive blank and drawing out to a fiber or by direct drawing out of the glass tube to form an optical waveguide, characterized in that an oxygen pressure of $p < 10$ mbar is established in the inner space of the glass tube during the collapsing or glass tube drawing-out process.

2. Method according to Claim 1, characterized in that the desired oxygen pressure is established by a mixture of oxygen with at least one other gas.

3. Method according to Claim 2, characterized in that a noble gas is admixed with the oxygen.

4. Method according to Claim 2, characterized in that nitrogen is admixed with the oxygen.

Description

The invention refers to a method for the production of an optical waveguide--which is made of pure SiO_2, at least in its inner core area--from a glass tube with a suitable refractive index distribution over the wall thickness, by collapsing this glass tube to form a massive blank and drawing out to form an optical waveguide or by indirect [sic; direct] drawing out of the glass tube to form an optical waveguide.

Important processes for the production of optical waveguides are the methods of coating the tube interior (MCVD, PCVD, PICVD methods). Thin layers of doped quartz glass are deposited on the inside of a quartz tube. The desired radial refractive index course is established by the selection and concentration of the doping agent of the individual layers, wherein the core has a higher refractive index than the jacket.

After the coating, the tube is collapsed in several steps at an elevated temperature to form a rod, which can be drawn out to an optical fiber. However, it is also possible to draw out an optical fiber directly from the described tube, without collapsing the tube to a rod beforehand.

The most frequently used core doping agent is germanium. One disadvantage of this doping agent is the dip in the refractive index in the core center, which arises during collapsing due to the evaporation of said doping agent. This reduces the transmission bandwidth in gradient index fibers.

In particular with monomode fibers, the bending losses are increased by the dip.

Moreover, transmission losses are theoretically increased by the doping, with respect to a pure SiO_2 core.

An optical waveguide with a pure SiO_2 core exhibits a dip and should theoretically have the lowest losses. However, the optical fibers produced up to now, with a pure SiO_2 core, clearly exhibit higher losses than theoretically expected.

To reduce transmission losses, Bachmann et al. proposed (Procee. IODC/ECOC 1985, Venice, pp. 81-85) adding small amounts of germanium to the core. The required lowering of the refractive index of the jacket occurred by doping with fluorine.

This state of the art has various disadvantages because of the germanium doping:

I. there is, once more, a refractive-index profile disturbance in the core area, which impairs the bending sensitivity of the optical fiber;

II. the sensitivity with respect to transmission-loss-increasing environmental influences, such as the effect of hydrogen, for example, when using optical fibers in undersea cables, or radiation, is increased;

III. high production costs because of the expensive germanium and the need for an expensive gas producer.

The goal of the invention is therefore to produce a low-loss optical waveguide with a pure SiO_2 core in a simple manner, in order to avoid the aforementioned disadvantages of the doped optical waveguide.

This goal is attained by the features indicated in the characterizing part of Claim 1.

It was surprising to attain a reduction of the losses with such a low O_2 pressure, since with such a low supply of oxygen, a specialist would have expected a reduction of SiO_2 to SiO and thus an increase in losses.

The procedure can be such that oxygen with an appropriate pressure is present as the only gas in the interior of the glass tube, or that at least one other gas is admixed with the oxygen, in order to establish the oxygen pressure.

An exemplified embodiment of the invention is explained below:

A quartz glass tube is coated on the inside, according to the PICVD method, as it is described in West German Patent No. 3,010,314. First, a coating with the mass flows of the gas components O_2, $SiCl_4$, CCl_2F_2 of 200, 50, and 1.5 mL/min, respectively, is applied as the optical waveguide jacket. A core layer of pure SiO_2 is then precipitated with the mass flows of 200 mL/min of O_2 and 50 mL/min for $SiCl_4$. Subsequently, the coated tube is heated to temperatures between 2000°C and 2400°C with a burner, wherein it collapses to from a rod in several steps.

During the collapsing, an oxygen/argon mixture, approximately under standard pressure, is conducted through the tube, wherein the oxygen partial pressure is 1 mbar before the entry of the gas mixture into the tube.

The blank thus produced is then drawn out to an optical fiber, which has the advantageous characteristics described above.

RWS TRANSLATION SOLUTIONS
5316 Hwy. 290 West, 330, Austin, Texas 78735
tel: (512) 899-1881 • fax: (512) 899-1626
Email: rws-austin@inetmail.att.net

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